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Hen2-446 – A B[E] STAR WITH A VARIABLE V/R RATIO

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Hen2-446 = IRAS 19419+2319, with coordinates: α=$19^h44^m05^s$ δ =+23°26′.8, was discovered by Henize (1967). Some low-excitation emission lines ([OI], FeII, HI) were discovered in the spectrum, and the object entered the Catalog of galactic planetary nebula (Perek & Kohoutek, 1967). Then the object was included in the list of emission-line objects with infrared excess (Allen & Swings, 1972, 1976). According to the modern classification this object is identified as a B[e] star (Lamers et al., 1998). Individual photometric measurements of Hen2-446 were provided by Allen & Swings (1972), Coyne et al. (1974) and Zacharias (2004). Our observations of Hen2-446 were begun in 1971 and were continued until 2010.

Observations were performed with the 0.7-m Cassegrain reflector AZT-8, located at the Observatory of Fessenkov Astrophysical Institute (AFIF) near Almaty. The earlier (1971 – 1995) estimations of the V magnitude were derived using the three-cascade image tube UM-92 plus a special film. The color system had a maximal sensitivity near 5460Å and a pass band about 800 Å, in accordance with Johnson's V band. Four nearby field stars were chosen as the secondary standards. (Their B and V-magnitudes were derived during photoelectric observations with the 1-meter telescope). A treatment procedure for the images, obtained with the image tube has been described in the paper Kondratyeva (2001). The intrinsic errors of differential photometry were equal to $0^m.03$–$0^m.07$ in dependence on the star's magnitudes.

Since 2000 our telescope has been equipped with a CCD ST-8 (1530 x 1020, 9μ) and B V Rc filters. All obtained frames were dark subtracted and flat fielded. The stars HD184740, HD184942 and HD185858 were adopted as standards. Expressions for transformation to the international system was made by measuring about 80 standard stars. The results of photometry are compiled in Table 1. Fig.1a displays variations of V mag versus HJD. Cyclic variations of V magnitude within $0^m.5$ – $0^m.8$ were accompanied by the gradual decrease of brightness (a line of trend in Fig.1a). The Discrete Fourier Transform of our normalized V magnitudes (the trend was excluded) showed a peak at frequency about 0.002521 d^{-1} (P=396.668d). The phase diagram for V according to the ephemeris: JDmin=2441577.480+396.668xE is presented in Fig.1c.

Spectral observations have been carried out with the original slit spectrograph, constructed in AFIF for faint emission objects (Denissyuk, 2003). The slit width equals to 3″ and 10″. A sample of gratings and objective lenses provided a spectral range from 3700 to 8200 Å. Spectrograms, obtained with the spectral resolution R=36000 were measured for the study of line profiles, and those with the R=9000–13000 were used for emission flux and EW determination.

All spectrograms were corrected for atmospheric extinction. There are emission lines of HI, HeI, [OI], [FeII] and possibly [NII], 6583Å in the spectrum of Hen2-446. The object is observed on a background of an extended HII region, and an appropriate long emission line of Hα is present on the spectrograms. This line together with the sky spectrum was measured on both sides of the stellar continuum and was subtracted from the observable spectrum of the object.

The absolute fluxes and equivalent widths for the Hα and Hβ are listed in Table 2. This is the case when the profiles of HI emission lines consist of two peaks with variable V/R ratio. The heliocentric radial velocities of all components are given in Table 3. (We estimate the errors in the V_r to be about $\pm$4km s^{-1}).

It turned out, that the radial velocities of the peaks were practically unchanged (within the limits of errors) during about 40 years. Position of an absorption line seems also to be persistent. Its negative velocity can specify an expansion of the outer absorbing layers of the disk or may be attributed to a proper motion of the star. No correlations were revealed between variations of EW(Hα) and V mag. Thus changes of EW depend mainly on the emission fluxes and may reflect variations of a size and gas density of the disk.

A period of V/R variations was not yet determined because our data points are distributed rather randomly. If the V/R ratios vary cyclically, they may arise from rotation of a circumstellar disk with a non-axisymmetric density distribution. In other case changes of V/R ratio may be caused by incidental density perturbations of the disk.

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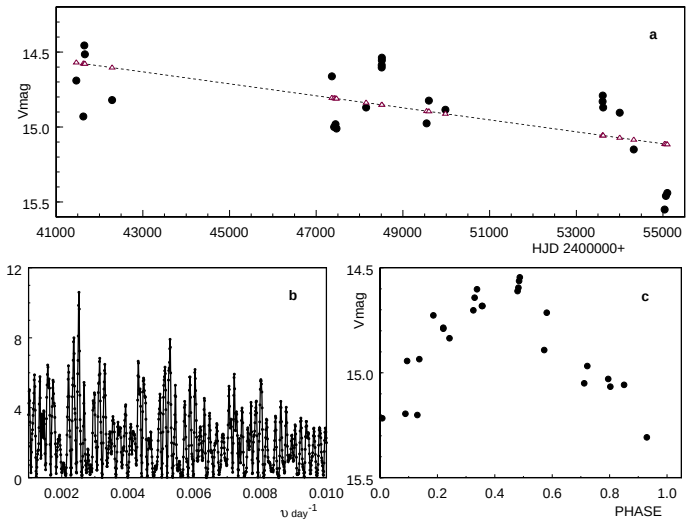

Figure 1. The results of photometry of Hen2-446. a – Vmag. versus HJD. b – DFT of the V magnitude measurements. c – the light curve.

*This version of the paper contains corrections, and differs from the one appeared on-line originally. Date of last modification: Mon Aug 1 09:46:18 CEST 2011

Table 1: Photometric results

Date	HJD	B	V	R
28.05.1972	41467.381		14.59±0.101	
07.11.1972	41629.173		14.93±0.13	
29.11.1972	41651.254		14.46±0.10	
13.12.1972	41665.038		14.52±0.11	
01.09.1974	42292.471		14.82±0.09	
18.07.1988	47361.313		14.56±0.10	
08.09.1988	47413.171		14.99±0.11	
11.10.1988	47446.288		14.98±0.09	
02.11.1988	47468.269		15.01±0.09	
16.09.1990	48151.235		14.87±0.08	
11.09.1991	48511.021		14.60±0.09	
12.09.1991	48512.146		14.59±0.08	
13.09.1991	48513.129		14.56±0.08	
14.09.1991	48514.123		14.56±0.07	
14.07.1994	49548.348		14.98±0.08	
02.09.1994	49598.256		14.82±0.09	
20.09.1995	49981.218		14.89±0.09	
25.08.2005	53608.217	15.92±0.06	14.83±0.03	
28.08.2005	53611.494	16.00±0.06	14.79±0.02	13.46±0.04
04.09.2005	53618.347		14.87±0.05	
05.09.2005	53619.196		14.86±0.05	
14.06.2006	54003.108		14.90±0.05	
12.08.2007	54325.254	16.34±0.06	15.15±0.03	13.93±0.04
23.07.2009	55036.350	16.55±0.06	15.55±0.04	14.20±0.04
23.08.2009	55067.215	16.68±0.06	15.46±0.03	
23.09.2009	55098.214	16.56±0.06	15.44±0.03	14.08±0.04

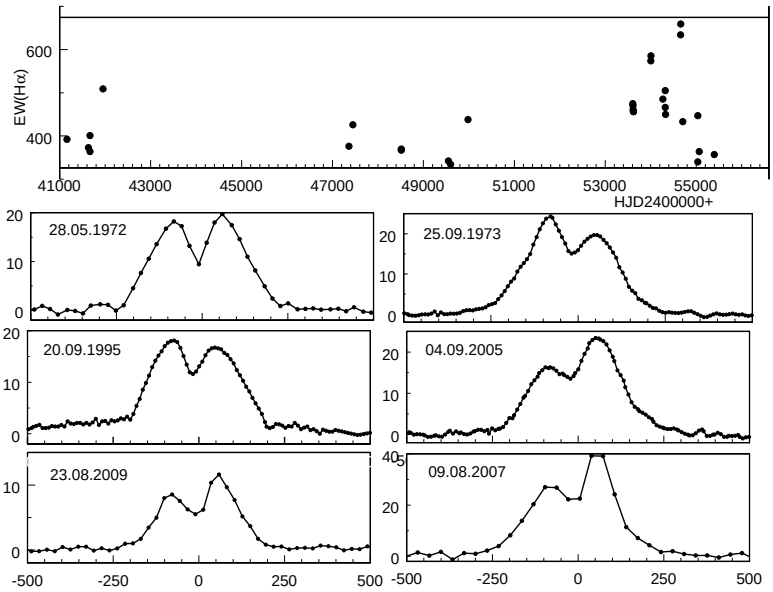

Figure 2. EW(Hα) vs HJD (the upper panel) and profiles of Hα for some dates. X-axis shows a heliocentric radial velocity, an Y-axis gives a ratio (I_λ-I_{cont})/I_{cont}

Table 2: Spectral results

Date	HJD 2400000+	EW(Hα) Å	σ Å	Fabs(Hα) erg cm^{-2}sec^{-1}	EW(Hβ) Å	σ Å	Fabs(Hβ) erg cm^{-2}sec^{-1}
24.07.1971	41157.300	392	28				
28.05.1972	41467.381	410	22				
07.11.1972	41629.173	373	33				
13.12.1972	41665.029	364	31				
26.09.1973	41952.158	509	45				
18.07.1988	47361.313	376	9				
08.09.1988	47413.163				30.8	2.2	
11.10.1988	47446.290	426	22				
02.11.1988	47468.271				31.3	2.5	
16.09.1990	48151.234				33	2.5	
11.09.1991	48511.038	367	25		29.6	2.3	
14.09.1991	48514.143	370	10		28.4	2.1	
14.07.1994	49548.350	342	18		28.1	1.8	
02.09.1994	49598.254	334	15				
20.09.1995	49981.217	438	21				
24.08.2005	53607.213	475	15				
25.08.2005	53608.217	470	19				
28.08.2005	53611.217	461	11	1.20E-12	27.0	1.9	8.49E-14
04.09.2005	53618.300	457	34	2.48E-12			
05.09.2005	53619.192	456	22	2.36E-12	36.7	2.2	9.27E-14
24.09.2006	54003.097	574	37				
26.09.2006	54005.333	585	29				
15.06.2007	54267.403	486	33				
05.08.2007	54318.250	466	22	1.52E-12			
06.08.2007	54319.229	505	27		30.6	1.1	5.28E-14
13.08.2007	54326.246	450	32	1.73E-12			
10.07.2008	54658.292	634	36	1.54E-12			
11.07.2008	54659.311	659	33	1.50E-12			
27.08.2008	54706.205	433	23				
22.07.2009	55035.181	347	29				
24.07.2009	55037.292	340	14				
23.08.2009	55067.236	364	17	1.27E-12			
19.07.2010	55397.299	357	14				

Table 3: Characteristics of the Hα profiles

Date	HJD 2400000+	V_r(red) km sec^{-1}	V_r(blue) km sec^{-1}	V_r(absorp) km sec^{-1}	FWHM Å	V/R
24.07.1971	41157.300	42.0	-81.0	-17.0	6.9	0.92
28.05.1972	41666.417	59.1	-82.6	-25.1	6.4	0.92
25.09.1973	41951.154	45.8	-79.0	-19.4	6.4	1.25
20.09.1995	49981.217	46.4	-72.3	-17.4	6.4	1.02
04.09.1995	53618.300	50.0	-73.4	-18.6	6.1	0.69
24.09.2006	54003.097	56.5	-84.6	-18.3	6.1	0.79
15.06.2007	54267.381	54.9	-92.3	-25.9	6.1	0.66
05.08.2007	54318.250	55.0	-79.4	-16.9	6.5	0.74
11.07.2008	54659.311	48.5	-81.9	-22.4	5.9	0.71
27.08.2008	54706.250	53.1	-84.1	-21.3	6.2	0.70
24.07.2009	55037.292	51.7	-72.3	-21.1	5.9	0.87
23.08.2009	55067.236	58.5	-78.3	-21.2	6.1	0.80
23.09.2009	55098.117	48.0	-88.6	-20.6	6.3	0.74
the mean	values	50.98±5.29	-81.77±5.62	-19.54±2.64	6.25±0.30	